

APPLICATION NO. 10/772,597

INVENTION: Decisioning rules for turbo and convolutional decoding

INVENTORS: Urbain A. von der Embse

Clean version of how the CLAIMS will read

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CLAIMS

WHAT IS CLAIMED IS:

10 Claim 1. (currently amended) A method for performing a new turbo decoding algorithm using a-posteriori probability $p(s, s' | y)$ in equations (13) for defining the maximum a-posteriori probability MAP, comprising::
using a new statistical definition of the MAP logarithm
15 likelihood ratio $L(d(k) | y)$ in equations (18)

$$L(d(k)) | y = \ln [\sum_{(s, s' | d(k)=1)} p(s, s' | y)] - \ln [\sum_{(s, s' | d(k)=0)} p(s, s' | y)]$$

20 equal to the natural logarithm of the ratio of the a-posteriori probability $p(s, s' | y)$ summed over all state transitions $s' \rightarrow s$ corresponding to the transmitted data $d(k)=1$ to the $p(s, s' | y)$ summed over all state transitions $s' \rightarrow s$ corresponding to the transmitted data $d(k)=0$,
25 using a factorization of the a-posteriori probability $p(s, s' | y)$ in equations 13 into the product of the a-posteriori probabilities

$$p(s, s' | y) = p(s | s', y(k)) p(s | y(j > k)) p(s' | y(j < k));$$

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using a turbo decoding forward recursion equation

$$p(s | y(j < k), y(k)) = \sum_{\text{all } s'} p(s | s', y(k)) p(s' | y(j < k))$$

for evaluating said a-posteriori probability $p(s'|y(j<k))$ in equations 14 using $p(s|s',y(k))$ as the state transition a-posteriori probability of the trellis transition path $s' \rightarrow s$ to the new state s at k from the previous state s' at $k-1$ and given the observed symbol $y(k)$ to update these recursions for the assumed value of the user data bits $d(k)$ equivalent to the transmitted symbol $x(k)$ which is the modulated symbol corresponding to $d(k)$,

10 using a turbo decoding backward recursion equation

$$p(s'|y(j>k-1)) = \sum_{\text{all } s} p(s|y(j>k))p(s'|s,y(k))$$

for evaluating the a-posterior probability $p(s|y(j>k))$ in equations 15 using said $p(s'|s,y(k)) = p(s|s',y(k))$ as the state transition a-posteriori probability of the trellis transition path evaluating the natural logarithm of the state transition a-posteriori probability $p(s|s',y(k)) = p(s'|s,y(k))$ equal to the new decisioning metric DX in equations 11, 16, defined by equation

$$\begin{aligned} \ln[p(s|s',y(k))] &= \ln[p(s'|s,y(k))] \\ &= \text{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k)) \\ &= DX \end{aligned}$$

25 wherein \underline{p} is the natural logarithm \ln of p , x^* is the complex conjugate of x , and $\ln[\underline{o}]$ is the natural logarithm of $[\underline{o}]$,

whereby said new state transition probabilities in said MAP 30 equations use said DX linear in $y(k)$ in place of the current use of the maximum likelihood decisioning metric $DM = [-|y(k) - x(k)|^2/2\sigma^2]$ which is a quadratic function of $y(k)$,

whereby said MAP turbo decoding algorithms provide some of the performance improvements demonstrated in FIG. 5,6 using said DX, and.

whereby this new a-posteriori mathematical framework enables 5 said MAP turbo decoding algorithms to be restructured and to determine the intrinsic information as a function of said DX linear in said $y(k)$.

10 Claim 2. (currently amended) A method for performing a new convolutional decoding algorithm using the MAP a-posteriori probability $p(s,s'|y)$ in equations 13, comprising::

15 using a new maximum a-posteriori principle which maximizes the a-posteriori probability $p(x|y)$ of the transmitted symbol x given the received symbol y to replace the current maximum likelihood principle which maximizes the likelihood probability $p(y|x)$ of y given x for deriving the forward and the backward recursive equations to implement convolutional decoding,

20 using the factorization of the a-posteriori probability $p(s,s'|y)$ in equations 13 into the product of said a-posteriori probabilities $p(s'|y(j < k))$, $p(s|s',y(k))$, $p(s|y(j > k))$ to identify the convolutional decoding forward state metric $a_{k-1}(s')$, backward state metric $b_k(s)$, and state 25 transition metric $p_k(s|s')$ as the a-posteriori probability factors

$$p_k(s|s') = p(s|s',y(k))$$

$$b_k(s) = p(s|y(j > k))$$

$$a_{k-1}(s') = p(s'|y(j < k)),$$

30

using a convolutional decoding forward recursion equation in equations 14 for evaluating said a-posteriori probability $a_k(s) = p(s|y(j < k), y(k))$ using said $p_k(s|s') = p(s|s',y(k))$ as 35 said state transition probability of the trellis transition

path $s' \rightarrow s$ to the new state s at k from the previous state s' at $k-1$,
using a convolutional decoding backward recursion equation in
equations 15 for evaluating said a-posteriori
5 probability $b_k(s) = p(s|y(j>k))$ using said
 $p_k(s'|s) = p(s'|s, y(k))$ as said state transition probability
of the trellis transition path $s \rightarrow s'$ to the new state s' at
 $k-1$ from the previous state s at k ,
evaluating the natural logarithm of said state transition
10 a-posteriori probabilities

$$\begin{aligned} \ln[p_k(s'|s)] &= \ln[p(s'|s, y(k))] \\ &= \ln[p(s|s', y(k))] \\ &= \ln[p_k(s|s')] \\ &= DX \end{aligned}$$

15 equal to the new decisioning metric DX in equations
16, and
implementing said convolutional decoding algorithms to
20 obtain some of the performance improvements demonstrated in
FIG. 5, 6 using said DX .

25 **Claim 3.** (currently amended) Wherein in claim 2 a method
for implementing the new convolutional decoding recursive
equations, said method comprising:
implementing in equations 14 a forward recursion equation
30 for evaluating the natural logarithm, \underline{a}_k , of a_k using the
natural logarithm of the state transition a-posteriori
probability $p_k = \ln[p(s|s', y(k))]$ of the trellis transition
path $s' \rightarrow s$ to the new state s at k from the previous state
 s' at $k-1$, which is equation

$$\underline{a}_k(s) = \max_{s'} [\underline{a}_{k-1}(s') + p_k(s|s')]$$

$$\begin{aligned}
 &= \max_{s'} [\underline{a}_{k-1}(s') + DX(s|s')] \\
 &= \max_{s'} [\underline{a}_{k-1}(s') + \text{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k))]
 \end{aligned}$$

wherein said $DX(s|s') = \underline{p}_k(s|s') = \underline{p}_k(s'|s) = DX(s'|s) = DX$ is the
5 new decisioning metric, and

implementing in equations 15 a backward recursion equation
10 for evaluating the natural logarithm, \underline{b}_k . of b_k using
the natural logarithm of said state transition a-posteriori
probability $\underline{p}_k = \ln[p(s'|s, y(k))] = \ln[p(s|s', y(k))]$ of the
trellis transition path $s \rightarrow s'$ to the new state s' at $k-1$ and
is equation

$$\underline{b}_{k-1}(s') = \max_s [\underline{b}_k(s) + DX(s'|s)].$$

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